Qualification of the damage induced by friction using X-ray Diffractometry

Agnes Fabre[a], Sébastien Jégou [a], Laurent Barrallier [a]

[a] Arts et Métiers ParisTech, MSMP Laboratory, 2, Cours des Arts et Métiers, 13617 Aix-en-Provence, F

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1. ABSTRACT

In a previous study, the capability of X-ray diffraction technique to qualify damage occurring during friction had been proven [1]. The purpose of this study is to complete this research in order to develop a method to quantify the damage induced by the friction loading.

1.1. Damage in materials

Generally in the first cycles of friction between two bodies, the " running-in" induces some changes in the geometry of the contact zone and some damage in the material close to the surface of contact. The location of the damage depends on the friction loading and on the material properties: on the surface for materials sensible to tensile effects and beneath the surface for those are more sensible to shear effects [2].

Moreover the damage concerning a large volume of material is difficult to correlate directly with a global physical variable. Directly linked with the local plastification of material, damage can be described with the notification of local changes in crystallites with the increase of dislocations [3].

1.2. XRD peak broadening

The X-ray diffraction (XRD) is an useful and well-known technique to analyse and characterize the material in terms of components (phasis) and textured microstructure, in terms of residual stresses. This technique uses directly the response of the crystallographic structure of the material as a gauge in the interference phenomenon of diffraction between the material and with an X-ray's beam. Different variables are used to define the state of the material. The position of the centre of the X-rays diffraction peak allows identifying the different components in terms of phases. Moreover, shift in position of the centre can used to determine mechanical state in terms of residual stress. Nevertheless, when the material is inhomogeneous induces changes in the shape of the XDR peak, typically a broadening effect. This is due to the defects inside the volume of material analysed, where are localized the coherent diffraction domains (CDD) of material which contribute to the diffraction phenomenon [4]. XDR is sensible to the dislocation density [5] and to the structure of dislocations. With the integral breadth (IB) chosen as criterion [4,6], broadening on XRD peaks can be used as an indicator of dislocation densities. In the volume of material studied, damage is linked to the dislocation density. IB can be used to characterize the effects of damage and to analyse changes in terms of damage of the volume studied.

1.3. Experimental approach

The material studied is an austenitic stainless steel (AISI 316L) with monophasic microstructure. XRD peaks will be recorded before and after friction test. In a previous study [1], friction tests are conduced between discs (316L) and cylinder (AISI 52100 steel). In this first study, experimental method was qualified to obtain relevant broadening effect after only 5 cycles of friction. The contact was chosen as linear between cylinder and flat parts, with 10 mm about sliding stroke, with frequency of 1Hz, and 160 N for a normal loading, in grease lubrication conditions.

In this current study, a new campaign will be conducted in order to qualify the repeatability of broadening effect and to quantify the changes in broadening effect in front of the number of cycles.
A second investigation will led in order to understand if broadening effect can be detected for lower loading, avoiding theoretical maximal stress (Hertz point) occurring over the yielding point.

1.4. Modelling approach

In order to complete, this last experimental investigation, the stress map beneath the surface will be described using a FEM approach, taking into account the friction loading combined with normal loading.

2. REFERENCES

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